

## CLAIMS

We claim:

1. An electrode assembly adapted for use with a fuel cell, comprising:  
an anode derived from a first planar silicon substrate;  
an electrolyte;  
a cathode derived from a second planar silicon substrate;  
wherein the anode and the cathode are spaced apart and substantially parallel to each other so as to define a spaced apart region, and wherein the electrolyte is interposed between the anode and the cathode.
2. The electrode assembly of claim 1 wherein the first and second planar silicon substrates are silicon wafers.
3. The electrode assembly of claim 1, further comprising a blocking media that is substantially impermeable to at least methanol and is substantially permeable to hydrogen atoms, wherein the blocking media is interposed between the anode and the cathode.
4. The electrode assembly of claim 3 wherein the blocking media is integrally connected to the cathode.
5. The electrode assembly of claim 3 wherein the blocking media comprises a metallic membrane.
6. The electrode assembly of claim 3 wherein the blocking media comprises palladium, niobium, tantalum, vanadium, or a combination thereof.
7. The electrode assembly of claim 3 wherein the blocking media is a plurality of proton conducting plugs.

8. The electrode assembly of claim 1 wherein the anode has a plurality of etched or micromachined flow channels.

9. The electrode assembly of claim 1 wherein the anode has a plurality of porous regions.

10. The electrode assembly of claim 9 wherein each of the plurality of porous regions contains a solid porous rectangular region having a volume of about  $3 \times 10^{-4}$  cm<sup>3</sup>.

11. The electrode assembly of claim 10 wherein the plurality of porous regions of the anode are nanoporous, mesoporous, and/or macroporous.

12. The electrode assembly of claim 10 wherein the plurality of porous regions of the anode are mesoporous, wherein each of the plurality of mesoporous regions comprises an ordered or random array of parallel pores.

13. The electrode assembly of claim 10 wherein the plurality of porous regions of the anode contain anode pore surfaces, wherein the anode pore surfaces have a catalyst thereon.

14. The electrode assembly of claim 13 wherein the catalyst comprises a plurality of noncontiguous chemisorbed metallic particles.

15. The electrode assembly of claim 13 wherein the catalyst is a chemisorbed bi-metallic catalyst derived from platinum and ruthenium precursors.

16. The electrode assembly of claim 1 wherein the cathode has a plurality of etched or micromachined flow channels.

17. The electrode assembly of claim 1 wherein the cathode has a plurality of porous regions.

18. The electrode assembly of claim 17 wherein the plurality of porous regions of the cathode are nanoporous, mesoporous, and/or macroporous.

19. The electrode assembly of claim 17 wherein the plurality of porous regions of the cathode are mesoporous, wherein each of the plurality of mesoporous regions comprise a random array of sponge-like interconnected pores having an open cell structure.

20. The electrode assembly of claim 17 wherein the plurality of porous regions of the cathode contain cathode pore surfaces, wherein the cathode pore surfaces have a catalyst thereon.

21. The electrode assembly of claim 20 wherein the catalyst comprises a plurality of noncontiguous chemisorbed metallic particles.

22. The electrode assembly of claim 20 wherein the catalyst comprises a chemisorbed metallic catalyst derived from a platinum precursor.

23. The electrode assembly of claim 1 wherein the electrolyte comprises a solid polymer electrolyte.

24. The electrode assembly of claim 23 wherein the solid polymer electrolyte comprises a perfluorosulfonic polymer membrane.

25. The electrode assembly of claim 13 wherein the anode pore surfaces having a catalyst thereon, further include at least a portion of the electrolyte thereon, wherein the electrolyte is a solid polymer electrolyte.

26. The electrode assembly of claim 25 wherein the solid polymer electrolyte is a thin film having a thickness ranging from about 0.05 to about 0.5 microns.

27. The electrode assembly of claim 20 wherein the cathode pore surfaces having a catalyst thereon, further includes at least a portion of the electrolyte thereon, wherein the electrolyte is a solid polymer electrolyte.

28. The electrode assembly of claim 27 wherein the solid polymer electrolyte is a thin film having a thickness ranging from about 0.1 to about 0.5 microns.

29. The electrode assembly of claim 1 wherein the electrolyte comprises first and second solid polymer electrolyte coatings and an acid, wherein the first solid polymer electrolyte coating is on the anode, and wherein the second solid polymer electrolyte coating is on the cathode, and wherein the acid is contained in an organic fuel that flows through the anode and the spaced apart region.

30. The electrode assembly of claim 29 wherein the organic fuel comprises water and an alcohol selected from the group consisting ethanol, propanol, methanol, or a combination thereof, and the acid is phosphoric acid, sulfuric acid, or a combination thereof.

31. The electrode assembly of claim 30 wherein the methanol and water are mixed together in about equal molar amounts, and wherein the acid is in amount of about 0.25 M.

32. An electrode assembly adapted for use with a fuel cell, comprising:  
an anode derived from a first planar silicon substrate, wherein the anode has integrally associated therewith a plurality of anode sol-gel derived support structures;  
an electrolyte;

a cathode derived from a second planar silicon substrate, wherein the cathode has integrally associated therewith a plurality of cathode sol-gel derived support structures;

wherein the anode and the cathode are spaced apart and substantially parallel to each other so as to define a spaced apart region, and wherein the electrolyte is interposed between the anode and the cathode.

33. The electrode assembly of claim 32 wherein the first and second planar silicon substrates are silicon wafers.

34. The electrode assembly of claim 32, further comprising a blocking media that is substantially impermeable to at least methanol and is substantially permeable to hydrogen atoms, wherein the blocking media is interposed between the anode and the cathode.

35. The electrode assembly of claim 34 wherein the blocking media is integrally connected to the cathode.

36. The electrode assembly of claim 34 wherein the blocking media comprises a metallic membrane.

37. The electrode assembly of claim 34 wherein the blocking media comprises palladium, niobium, tantalum, vanadium, or a combination thereof.

38. The electrode assembly of claim 34 wherein the blocking media is a plurality of proton conducting plugs.

39. The electrode assembly of claim 34 wherein the anode has a plurality of etched or micromachined flow channels.

40. The electrode assembly of claim 32 wherein each of the plurality of anode and cathode sol-gel derived support structures contains a solid porous rectangular region having a volume of about  $3 \times 10^{-4} \text{ cm}^3$ .

41. The electrode assembly of claim 40 wherein the solid porous rectangular regions of the anode are nanoporous, mesoporous, and/or macroporous.

42. The electrode assembly of claim 40 wherein the solid porous rectangular regions of the anode are mesoporous, and wherein each of the plurality of mesoporous regions comprise a random array a sponge-like interconnected pores having an open cell structure.

43. The electrode assembly of claim 40 wherein the solid porous rectangular regions of the anode contain anode pore surfaces, wherein the anode pore surfaces have a catalyst thereon.

44. The electrode assembly of claim 43 wherein the catalyst comprises a plurality of noncontiguous chemisorbed metallic particles.

45. The electrode assembly of claim 43 wherein the catalyst comprises a chemisorbed bi-metallic catalyst derived from platinum and ruthenium precursors.

46. The electrode assembly of claim 32 wherein the cathode has a plurality of etched or micromachined flow channels.

47. The electrode assembly of claim 40 wherein the solid porous rectangular regions of the cathode are nanoporous, mesoporous, and/or macroporous.

48. The electrode assembly of claim 47 wherein the solid porous rectangular regions of the cathode are mesoporous, wherein each of the plurality of

mesoporous regions comprise a random array of sponge-like interconnected pores having an open cell structure.

49. The electrode assembly of claim 48 wherein the solid porous rectangular regions of the cathode contain cathode pore surfaces, wherein the cathode pore surfaces have a catalyst thereon.

50. The electrode assembly of claim 49 wherein the catalyst comprises a plurality of noncontiguous chemisorbed metallic particles.

51. The electrode assembly of claim 49 wherein the catalyst comprises a chemisorbed metallic catalyst derived from a platinum precursor.

52. The electrode assembly of claim 32 wherein the electrolyte comprises a solid polymer electrolyte.

53. The electrode assembly of claim 52 wherein the solid polymer electrolyte comprises a perfluorosulfonic polymer membrane.

54. The electrode assembly of claim 43 wherein the anode pore surfaces having a catalyst thereon, further include at least a portion of the electrolyte thereon, wherein the electrolyte comprises a solid polymer electrolyte.

55. The electrode assembly of claim 54 wherein the solid polymer electrolyte is a thin film having a thickness ranging from about 0.05 to about 0.5 microns.

56. The electrode assembly of claim 49 wherein the cathode pore surfaces having a catalyst thereon, further include at least a portion of the electrolyte thereon, wherein the electrolyte comprises a solid polymer electrolyte.

57. The electrode assembly of claim 56 wherein the solid polymer electrolyte is a thin film having a thickness ranging from about 0.05 to about 0.5 microns.

58. The electrode assembly of claim 32 wherein the electrolyte comprises first and second solid polymer electrolyte coatings and an acid, wherein the first solid polymer electrolyte coating is on the anode, and wherein the second solid polymer coating is on the cathode, and wherein the acid is contained in an organic fuel that flows through the anode and the spaced apart region.

59. The electrode assembly of claim 58 wherein the organic fuel comprises water and an alcohol selected from the group consisting ethanol, propanol, methanol, or a combination thereof, and the acid is phosphoric acid, sulfuric acid, or a combination thereof.

60. The electrode assembly of claim 59 wherein the methanol and water are mixed together in about equal molar amounts, and wherein the acid is in amount of about 0.25 M.

61. The electrode assembly of claim 1, further comprising a spacing structure, wherein the spacing structure spans across the spaced apart region and connects the anode to the cathode.

62. The electrode assembly of claim 32, further comprising a spacing structure, wherein the spacing structure spans across the spaced apart region and connects the anode to the cathode.

63. An electrode adapted for use with a fuel cell, comprising:  
a silicon substrate that functions as a current conductor, wherein the silicon substrate has a plurality of pores that define pore surfaces, wherein at least a portion of the pore surfaces have a catalyst thereon, wherein the catalyst is derived from one or more metallic precursors chemisorbed onto at least the pore surfaces.

64. An electrode adapted for use with a fuel cell, comprising:  
a sol-gel derived support structure that functions as a current conductor,  
wherein the sol-gel derived support structure has a plurality of pores that define pore surfaces,  
wherein at least a portion of the pore surfaces have a catalyst thereon, wherein the catalyst is  
derived from one or more metallic precursors chemisorbed onto at least the pore surfaces.

65. A hydrogen or hydrocarbon fuel cell, comprising the electrode  
assembly of claim 1 or 32.